# INTEGRAL END CONNECTION FOR TUBE FITTING



## Background of Invention

The present invention relates to a fitting for connecting a first fluid device with a second fluid device. The fluid devices may be tube or pipe ends or may be another flow element such as a valve, union, flow restrictor and so on. The invention is particularly useful, although not exclusive to, plastic, polymer and resin type tubing and pipe. A typical material suitable for the fitting is PFA tubing.

The fitting of the present invention relates to a prior art fitting described in United States Patent Nos. 5,743,572 and 6,045,164, the entire disclosures of which are fully incorporated herein by reference. This prior art fitting is sold commercially by Nippon Pillar Packing Co., Ltd., as model S300. Fig. 1 herein is a longitudinal cross-sectional view of the prior art fitting described in the referenced patents.

Fig. 1 shows a fitting A that includes an end connection body or fitting body B for connection with a valve body or other fluid device (not shown), for example, by welding or by an adhesive or by other suitable methods. The fitting body B has a threaded end portion C that receives a tube end E. The fitting A also includes a threaded single piece nut F that is screwed on the threaded end portion of the body B. The inner diameter of the nut F is great enough so that the nut can be slipped over the tube end E prior to assembly and make up of the fitting A.

The fitting A further includes a sleeve D that has a portion I that bulges radially outward. The sleeve portion I is press-fit into the tube end E as part of the fitting assembly process after the nut F is already positioned on the tube end. The step of press-fitting the sleeve D into the tube end E requires a hot or cold flaring of the tube end in the field. The opposite end of the sleeve D, that projects out of the tube end E, includes a cylindrical connection portion H.

The body B has an annular groove G that receives the projecting cylindrical portion H of the sleeve D. The nut F has an annular edge J that pushes against the bulge portion I of the tube end E as the nut F is tightened onto the body B. An optional gage ring K may be used to gauge how tightly the nut F should be assembled onto the body B.

## Summary of Invention

The present invention relates to a tube fitting and to an end connection for a tube fitting. The fitting and end connection relate to the fitting shown in the above identified US Patents, and are usable therewith while eliminating the separate sleeve and the step of forcing the sleeve into the tube end to deform the tube end to form the bulge.

In one embodiment, the invention relates to an end connection for a tube fitting, comprising a tubular member having a first end joinable to a fluid device and a second end. The second end of the tubular member has an end configuration that can be mated with a second end connection. The tubular member has a circumferential bulge axially behind the second end.

In another embodiment, the invention relates to a tube fitting comprising a first end connection comprising a tubular member having a first end joinable to a first fluid device and a second end; and a second end connection joinable to a second fluid device.. The second end of the tubular member has an end configuration that can be mated with the second end connection, and the tubular member has a circumferential bulge axially behind the second end.

In a further embodiment, the invention relates to a tube fitting for connecting a first fluid device with a second fluid device, the fitting comprising a fitting body for connection with the first fluid device, the fitting body having an axis. The fitting also comprises a tubular member for connection with the second fluid device, and a nut rotatable on the fitting body about the axis to secure the fitting body coaxially to the tubular member thereby to connect the first fluid device with the second fluid device. The fitting body has a connector groove. The tubular member has a connector end portion that fits into the connector groove of the fitting body, and a radially outward bulge with a seal surface and a driven surface on opposite ends of the bulge. The fitting body has a flange that fits over the connector end portion of the tubular member and that has an internal seal surface for engagement with the seal surface on the bulge of the tubular member.

The nut is engageable with the driven surface on the tubular member to drive the tubular member into sealing engagement with the seal surface on the fitting body.

In still another embodiment, the invention relates to a tube fitting for connecting a first fluid device with a second fluid device. The tube fitting comprises a fitting body for connection with the first fluid device, the fitting body having an axis and having a connector groove. A tubular member for connection with the second fluid device has a connector end portion that fits into the connector groove of the fitting body, and a bulge that is spaced apart along the length of the tubular member from the connector end portion. A nut is threadably rotatable on the fitting body about the axis to secure the fitting body coaxially to the tubular member thereby to connect the first fluid device with the second fluid device. The outer diameter of the bulge on the tubular member is greater than the inner diameter of the nut. The bulge on the tubular member is clamped axially between the nut and the fitting body to secure the tubular member to the fitting body.

**Brief Description of the Drawings**

The foregoing and other features of the present invention will become apparent to one skilled in the art to which the present invention relates upon consideration of the following description of the invention with reference to the accompanying drawings, in which:

Fig. 1 is a longitudinal sectional view of a prior art fitting;

Fig. 2 is a longitudinal sectional view of a fitting in accordance with a first embodiment of the present invention;

Fig. 3 is an exploded view of a tube end and nut that form part of the fitting of Fig. 2;

Fig. 4 is an exploded view of a nut assembly that forms part of the fitting of Fig. 2;

Fig. 5 is a sectional view of a valve including inlet and outlet conduits that are adapted for use with a fitting of the present invention;

Fig. 6 is a sectional view of another valve including inlet and outlet conduits that are adapted for use with a fitting of the present invention;

Fig. 7 is a sectional view of a sweep elbow including end portions having fittings of the present invention;

Fig. 8 is a sectional view of a union including end portions having fittings of the present invention;

Fig. 9 is a sectional view of a flow restrictor including end portions having fittings of the present invention;

Fig. 10 is a sectional view showing the flow restrictor of Fig. 9 installed onto a valve;

Fig. 11 is a sectional view similar to Fig. 8 of a union including one end portion having a fitting of the present invention and the other end portion having a flared end fitting;

Fig. 12 is a view similar to Fig. 2 of a fitting in accordance with another embodiment of the invention, including rounded sealing surfaces rather than conical sealing surfaces, and showing an optional construction of the nut assembly;

Figs. 13-16 are a series of views illustrating make up of a fitting in accordance with a further embodiment of the invention; and

Fig. 17 is a view similar to Fig. 2 showing a fitting in accordance with still another embodiment of the invention,

**Detailed Description**

The present invention relates to a tube fitting for connecting a first fluid device with a second fluid device. A tube fitting in accordance with the invention may take differing forms and may be used in conjunction with differing fluid devices such as tube or pipe ends, valves, unions, flow restrictors, and so on. As representative of the invention, Fig. 2 illustrates one tube fitting 10 constructed in accordance with the invention. The tube fitting 10 includes a tubular

member or first end connection 20, a tube fitting body or second end connection 30, and a nut assembly 100.

The tubular member 20 has a first end 22 and a second end 24. The first end 22 of the tubular member 20 is attached to or integral with (formed as one piece with) a flow device, shown schematically at 26, such as a valve, a union, a tube, a restrictor, etc. Thus, the tubular member 20 might in some cases be part of the flow device 26 that is being connected by the tube fitting 10, in addition to being part of the tube fitting itself. The tubular member 20 preferably is machined or molded from the same stock as (as one piece with) the flow device 26, or alternatively may be a separately machined or molded part that is attached in a suitable manner, such as by welding, to the flow device 26. The second end or connector end 24 of the tubular member 20, as described below in detail, replicates the connector portion H of the separate sleeve D of the prior art fitting A (Fig. 1)

The tube fitting body 30, described below in detail, may be identical to the fitting body B of the prior art fitting A (Fig. 1). The fitting body 30 has a base portion 32 that is attached to or integral with a second flow device, shown schematically at 34, which may also be a valve, a union, a tube, a restrictor, etc.

The first end 22 of the tubular member 20 includes a tube wall 40 having parallel, cylindrical, inner and outer side surfaces 42 and 44 centered on an axis 46. The inner side surface 42 defines a fluid flow passage 48 of the tubular member 20.

The tubular member 20 has a circumferential bulge portion 50 intermediate the first and second ends 22 and 24. In the area of the bulge portion 50, the outer side surface 44 of the tubular member flares 20 radially outward with a frustoconical driven surface 52, a cylindrical surface 54, and a frustoconical seal surface 56, to form the thickened wall of the bulge portion. The inner side surface 42 has a constant diameter along the length of the bulge 50.

The bulge portion 50 is radially thicker because the outer side surface 44 is flared radially outward. The outer side surface 44 continues axially with a cylindrical surface portion 58 that extends axially from the seal surface 56. The inner side surface 42 of the tubular member 20 (Fig. 3) continues uninterrupted, at a constant diameter, for most of the length of the second end 24 of the tubular member 20.

The outer surface 44 of the tubular member 20 as thus formed has the same bulged configuration as the outer surface of the flared tube end E (Fig. 1) of the prior art fitting A after it is flared by inserting the sleeve D. The integral bulge portion 50 of the present invention eliminates the need to flare a tube end onto a sleeve as is done in the prior art design. Rather, the circumferential bulge 50 and second end 24 of the tubular member 20 replace the separate sleeve D and flared tube end of the prior art design.

The second end or connector end 24 of the tubular member 20 includes radially inner and outer flanges 60 and 62 with a groove 64 between them. The outer flange 62 is formed as a cylindrical projection. The projection 62 has the same geometry as the corresponding end H of the conventional separate sleeve D (Fig. 1) of the prior art fitting. Specifically, the projection 62 (Fig. 3) has an outer side surface 66 that is a continuation of the cylindrical surface 58. The projection 62 has an inner side surface 68 that is parallel to the outer side surface 66. A frustoconical surface 70 extends between the inner side surface 68 and an annular, radially extending end surface that extends to the outer side surface 66 of the projection 62.

The radially inner flange 60 of the connector end 24 of the tubular member 20 is formed as an annular sealing rib that does not project as far as the outer flange 62. The sealing rib 60 has the same geometry as the corresponding portion of the conventional separate sleeve D (Fig. 1) of the prior art fitting A. The sealing rib 60 (Fig. 3) has a tapered outer side surface 72 and a tapered inner side surface 74.

The fitting body, or second end connection, 30 may be the same as the fitting body B (Fig. 1) and as described in the above-incorporated patents. The fitting body 30 (Fig. 3) preferably is machined from the same stock as the flow device 34, or alternatively may be a separately machined or molded part having a base portion that is attached in a suitable manner, such as by welding, to the flow device.

The fitting body 30 has two radially spaced, annular flanges 80 and 82 that project axially from the base portion 32. The radially inner flange 82 defines a flow passage 84 that forms a continuation of the flow passage 48 in the tubular member 20 when the tubular member is assembled to the body 30. The inner flange 82 has substantially the same diameter as the sealing rib 60 of the connector end 24 of the tubular member 20.

The radially outer flange 80 of the fitting body 30 is substantially longer than the inner flange 82 and thus projects farther axially from the base portion 32. The outer flange 80 has a generally cylindrical configuration including an externally threaded outer surface 86 and a smooth inner surface 88. The inner surface 88 has substantially the same diameter as the cylindrical outer surface 66 of the second end 24 of the tubular member 20, so that the outer flange 80 is adapted to receive the second end of the tubular member. The inner surface 88 terminates in a gently tapered inner end surface 90 that extends axially and radially outwardly to an annular end surface 92 of the outer flange 80.

The inner surface 88 of the outer flange 80 is located radially outward of the inner flange 82. An annular, open-ended groove 94 is defined between the flanges 80 and 82. The bottom of the groove 94 is an annular surface 96 that faces away from the base portion 23 of the body 30. The groove 94 has substantially the same diameter as the cylindrical projection 62 on the connector end 24 of the tubular member 20, and thus is adapted to receive the cylindrical projection.

The nut assembly 100 shown in the embodiment of Figs. 2-4 is a split nut assembly including four parts. Specifically, the split nut assembly 100 includes a threaded nut 102, a split ring 104 (shown assembled in Fig. 3) and a retainer ring 106. A split nut concept is incorporated in this embodiment, because a one piece nut could not be slipped over the bulge portion 50 of the tubular member 20, in a direction from the second end 24 (from the right as viewed in Fig. 3).

The threaded nut 102 (Fig. 4) includes a main body portion 110 with internal threads 112 for engagement with the external threads 86 on the fitting body 30. The threaded nut 102 has a reduced diameter end portion 114 with a conically tapered inner surface 116 that extends from a shoulder or step 118. Inward of the shoulder 118 is a retaining groove 120. The diameter of the shoulder 118 is selected to be greater than the maximum outer diameter of the bulge 50 in the tubular member 20. As a result, the nut 102 can be slipped onto the tubular member 20 from the direction of the connector end 24. The reduced diameter end portion 114 of the nut 102 also has a cylindrical outer surface 122.

The split ring 104 includes two identical 180° segments 130 and 132 that are assembled as in Fig. 3 to form the split ring. The split ring 104 has a tapered outer surface 136 that generally conforms to the tapered surface 116 of the nut 102. A lip or edge 138 extends radially outward from the narrow end of the tapered surface 116. The dimensions of the lip 138 are selected so that the lip has a snap fit in the retaining groove 120 of the nut 102. The split ring 104 has an annular back end face 140. The split ring 104 further includes a tapered drive surface or shoulder 142.

When the split ring 104 is assembled, its inner surface 144 has a diameter that is less than the diameter of the bulge 50 on the tubular member 20. As a result, the split ring 104 can not be mounted onto the tubular member 20, by sliding over the bulge 50, when the split ring is assembled as one piece.

The retaining ring 106 of the nut assembly 100 has a cylindrical main body portion 150 and an annular shoulder 152 that extends radially inward from one end of the main body portion. The shoulder 152 has an annular shoulder surface 154 that is presented toward the split ring 104. The shoulder surface 154 is adapted to engage the back end surface 140 of the split ring 104, to retain the split ring inside the nut body 102, as described below. The main body portion 150 of the retaining ring 106 has a cylindrical inner surface 156 that is sized to have a press fit on the outer surface 122 of the reduced diameter end portion 114 of the nut 102.

The retaining ring 106 and the nut body 102 are large enough in inner diameter to slip over the bulge portion 50 of the tubular member 20 (moving in a direction from right to left as viewed in Figs. 2 and 3). The assembled split ring 104, however, is not. Therefore, the two pieces 130 and 132 of the split ring 104 are placed together on opposite sides of the tube wall 40, at a location between the bulge 50 and the flow device 26. The split ring 104 is then assembled with the nut body 102 by moving the lip 138 of the split ring past the shoulder 118 of the nut body and snapping it into the retaining groove 120 in the nut body. Then, the retaining ring 106 is pressed onto the end portion 114 of the nut body 102, to prevent the split ring 104 from being removed from the nut body. The multiple pieces of the nut assembly 100 are thus joined as one unitary assembly for cooperation with the other parts of the fitting 10.

The connector end 24 of the tubular member 20 is inserted into, or plugged into, the fitting body 30. The cylindrical projection 62 of the connector end 24 of the tubular member 20 fits tightly into the annular groove 94 in the fitting body 30. The outer side surface 66 of the cylindrical projection 62 engages the inner side surface 88 of the outer flange 80 of the fitting body 30. The inner side surface 68 of the cylindrical projection 62 engages the outer side surface of the inner flange 82 of the fitting body 30.

The sealing rib 60 of the tubular member 20 engages and is pressed tightly against the inner flange 82 of the fitting body 30. At the same time, the tapering seal surface 56 of the bulge

portion 50 of the tubular member 20 engages the tapered inner end surface 90 of the outer flange 80 of the fitting body 30.

The nut 100 is then screwed onto the fitting body 30. The internal thread 112 of the nut body 102 threadedly engages the external thread 86 of the fitting body 30. As the nut 100 is rotated on the fitting body 30, the nut is drawn axially toward the fitting body (in a direction to the right as viewed in Fig. 2).

As the nut 100 moves along the fitting body 30, the split ring 104 engages the bulge 50 on the tubular member 20. Specifically, the drive surface 142 of the split ring 104 engages the driven surface 52 on the bulge 50 of the tubular member 20. The force exerted by the moving nut assembly 100 is transferred to the tubular member 20, and the tubular member is pushed tightly into engagement with the fitting body 30. The seal surface 56 on the bulge 50 of the tubular member 20 engages the tapered inner end surface 90 on the outer flange 80 of the fitting body 30.

When the nut 100 is fully tightened on the fitting body 30, the bulge portion 50 of the tubular member 20 is captured axially between the split ring 104 of the nut assembly 100 and the outer flange 80 of the fitting body 30. The material of the tubular member 20 is compressed between the drive surface 142 of the split ring 104 of the nut assembly 100, on the one hand, and the tapered inner surface 90 of the outer flange 80 of the fitting body 30, on the other hand. The material of the bulge 50 of the tubular member 20 is deformed at this location, forming a primary seal. Also, a secondary seal is formed at the location where the drive surface 142 of the split ring 104 engages the driven surface 52 of the bulge 50 of the tubular member 20.

At the same time, the cylindrical projection 62 of the connector end 24 of the tubular member 20 fits tightly into the annular groove 94 in the fitting body 30, deforming and sealing against the fitting body. The outer side surface 66 of the cylindrical projection 62 seals against the inner side surface 88 of the outer flange 80 of the fitting body 30. The inner side surface 68

of the cylindrical projection 62 engages and seals against the outer side surface of the inner flange 82 of the fitting body 30. Further, the sealing rim 60 of the tubular member 20 engages and seals against the inner flange 82 of the fitting body 30.

It can thus be seen that the formation of the bulge portion, or integral sleeve, 50 as part of the tubular member 20 itself, eliminates the need for the separate sleeve D and the tube wall deforming step of the prior art. The use of the split nut assembly 100 makes it possible to utilize a tubular member 20 with a pre-formed bulge portion 50, during make up of the fitting 10.

Figs. 5-11 illustrate some exemplary fluid devices that use fittings in accordance with the invention. Fig. 5 illustrates in longitudinal cross-section a valve 170. The valve 170 includes a valve body 172 having an inlet conduit 176 and an outlet conduit 174 that open to a valve cavity 178.

A tubular member 20 with an integral bulge 50, identical to the tubular member shown in Figs. 2-4, is formed onto the inlet conduit 176, being machined thereon as one piece or being attached as a separate piece in a manner such as by welding. Similarly, a tubular member 20 with an integral bulge 50 is formed onto the outlet conduit 174, being machined thereon as one piece or being attached as a separate piece in a manner such as by welding.

The tubular members 50 allow the valve 170 to be connected into a fluid circuit using fittings 10 as described above. It should be noted that the invention is applicable to a valve or other fluid device using only one tubular member and fitting, not two.

Fig. 6 illustrates a valve 190 similar to the valve 170 shown in Fig. 5. In the valve 190, a tubular member 192 with an integral bulge 194 is provided on the inlet conduit 196 and a fitting body 198 is provided on the outlet conduit 200. Preferably, but not necessarily, the integral bulge 194 and the fitting body 198 are integrally machined with, or formed as one piece with, the valve body 202. Fig. 6 also illustrates the split nut assembly 100 installed on the tubular member 192, prior to make up of the fitting that includes the tubular member.

Figs. 7, 8, 9 and 10 illustrate additional exemplary but not limiting uses of the integral bulge concept. In Fig. 7, an integral bulge 50 is formed onto one end of a curved piece of tubing or pipe 210 that can be used, for example, as a sweep elbow in a fluid circuit. An integrally machined or otherwise attached fitting body 30 is provided on the opposite end of the elbow 210. Again, the split nut assembly 100 is illustrated as installed on the integral bulge 50.

Fig. 8 illustrates the invention used with a union 212. The union 212 includes a generally cylindrical union body 214. The union body 214 has a constant diameter central fluid passageway 216. Integral bulges 50 are machined on or otherwise formed as one piece with opposite ends of the union body 214. Split nut assemblies 100 are also illustrated as being installed on the ends of the union body 214. Alternatively, a fitting body like the fitting body 30 could be provided on either or both of the ends of the union body 214.

Fig. 9 illustrates the invention used with a flow restrictor 220. The flow restrictor 220 is similar to the union 214 of Fig. 8, with the exception that its central passageway 222 includes a reduced diameter portion 224 that functions as a flow restrictor. Fig. 9 illustrates the flow restrictor 220 with an integral bulge 50 and a split nut assembly 100 on one end, and an end connector 30 on the other end.

Fig. 10 illustrates the flow restrictor 220 installed onto a valve 230. In this example, the valve 230 includes an integrally machined fitting body 30 at the outlet port 232. A split nut assembly 100 is used to couple the fitting body 30 to one end of the flow restrictor 220 having an integral bulge 50 thereon. The opposite end of the flow restrictor 220 in this example has a fitting body 30 thereon.

Fig. 11 illustrates a union 234 that is similar to the union 212 of Fig. 8. The union 234 includes a generally cylindrical union body 236. An integral bulge 50 and a split nut assembly 100 are located on one end of the union body 236. A standard flared fitting end 238 is provided on the other end of the union body 236.

Fig. 12 illustrates a fitting 10a in accordance with another embodiment of the invention. The fitting 10a is similar to the fitting 10 (Fig. 2). Parts of the fitting 10a that are similar or identical to corresponding parts of the fitting 10 are given the same reference numerals with the suffix "a" added to distinguish them.

The fitting 10a (Fig. 12) includes a tubular member 20a having a bulged portion 50a that is configured somewhat differently than the bulged portion of the tubular member 20 of the fitting 10. Specifically, the bulged portion 50a has a rounded outer surface 53 that extends between the cylindrical outer surface 44a of the tube wall 40a and the larger diameter cylindrical outer surface 58a of the end connector portion 24a. The split ring 104a has a drive surface 142a that can be rounded as shown to conform to the outer surface 53 of the bulge 50a, or that can alternatively have a non-conforming configuration. The outer flange 80a of the fitting body 30a has a rounded inner end surface 90a.

When the fitting 10a is made up as in Fig. 12, the rounded drive surface 142a of the split ring 104a and the rounded end surface 90a of the fitting body 30a engage the rounded outer surface 53 of the bulge 50a of the tubular member 20a. This rounded configuration of the parts (rather than the planar or angled surface configurations shown in Fig. 2) may be preferable for sealing and/or other properties of a fitting in accordance with the present invention.

Figs. 13-16 are a series of views illustrating make up of a fitting 10b in accordance with another embodiment of the invention. The fitting 10b is similar to the fitting 10 (Fig. 2). Parts of the fitting 10b that are similar or identical to corresponding parts of the fitting 10 are given the same reference numerals with the suffix "b" added to distinguish them.

The fitting 10b includes a fitting body 30b that is the same as the fitting body 10b. The fitting 10b also includes a tubular member 20b that is somewhat different from the tubular member 20 of the fitting 10. The tubular member 20b has a tubular wall 40b that terminates in an enlarged diameter connector end portion 24b similar to the connector end portion 24 of the

tubular member 20. Instead of having a bulged portion spaced apart from the connector end portion, however, the tubular member 20b has a cylindrical flange 240 that extends axially from the enlarged diameter connector end portion 24b, in a direction toward the tubular wall 40b. The flange 240 is spaced radially outward from the tubular wall 40b and thus the tubular member 20b has a relatively deep groove 242 between the flange and the tubular wall.

The fitting 10b includes a single piece nut 250. The nut 250 has a cylindrical inner periphery 252 that has an inside diameter equal to the outside diameter of the end connector portion 24b and flange 240 of the tubular member 20b. The nut 250 has on its inner periphery 242 a resilient flange 254 that projects axially and curves radially inward from a location about half way along the length of the nut 250, in a direction so that it is disposed radially inward of the internal thread 112b on the nut. Because the flange 254 is curved radially inward, when in a free state it has a smallest diameter at its terminal end 256 that is smaller than the outside diameter of the tubular member end connector portion 24b. The flange 254 is spaced radially inward from the internal thread 112b and as a result the nut 250 has a groove 258 between the flange 254 and the internal thread.

During make up of the fitting 10b, the tubular member 20b is inserted into the nut 250 as shown sequentially in Figs. 13, 14 and 15. The connector end portion 24b of the tubular member 20b passes inward of the cylindrical inner surface 252 of the nut 250 and radially inward of the flange 254 on the nut. The tubular member 20b forces the flange 254 on the nut 250 to expand radially outward. The material of the flange 254 may stretch, or the flange may have slots or a serrated configuration, or another radially non-continuous configuration, to enable the flange to flex outwardly more easily. When the connector end portion 24b of the tubular member 20b, including its flange 240, has moved completely past the flange 254 on the nut 250, the flange on the nut contracts radially inward to overlie the outer surface of the tubular wall 40b of the tubular member.

The tubular member 20b is then drawn axially in the opposite direction. The flange 240 of the tubular member 20b moves into the groove 258 in the nut 250, radially outward of the flange 254 of the nut. The flange 240 of the tubular member 20b is bulged radially outward as this interengagement of the parts 20b and 250 occurs. The flange 254 may engage the bottom surface 244 of the groove 242 and deform into the corner of the groove to further support the flange 240.

The resulting assembly of the tubular member 20b and the nut 250 has an exposed, rounded bulge on the outer periphery of the tubular member. When the assembly of the tubular member 20b and the nut 250 is joined to the fitting body 30b as shown in Fig. 16, the flange 240 on the tubular member is captured between the outer flange 8b on the fitting body 30b and the flange 254 on the nut 250. In this way, the fitting 10b utilizes the existing fitting body 30b with a bulged tubular member 20b and a one-piece nut 250.

Fig. 17 illustrates a fitting 10c in accordance with another embodiment of the invention. The fitting 10c is similar to the fitting 10 (Fig. 2). Parts of the fitting 10c that are similar or identical to corresponding parts of the fitting 10 are given the same reference numerals with the suffix "c" added to distinguish them.

The fitting 10c includes a nut assembly 100c that may be made of fewer than the four pieces of the nut assembly 100 shown in Fig. 2. Specifically, the dashed lines 101 in Fig. 17 between the retaining ring 106c and the nut body 102c indicate that the retaining ring may be formed as one piece with the nut body. Alternatively, the dashed lines 103 in Fig. 17 between the split ring 104c and the nut body 102c indicate that the split ring may be formed as one piece with the nut body. Further, the split ring and the retaining ring and the nut body may all be formed as one piece. With any of these alternatives, a different assembly sequence may be needed, and or an elastic deformation of one or more of the parts during assembly.

From the above description of the invention, those skilled in the art will perceive improvements, changes, and modifications in the invention. Such improvements, changes, and modifications within the skill of the art are intended to be included within the scope of the appended claims.